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AND

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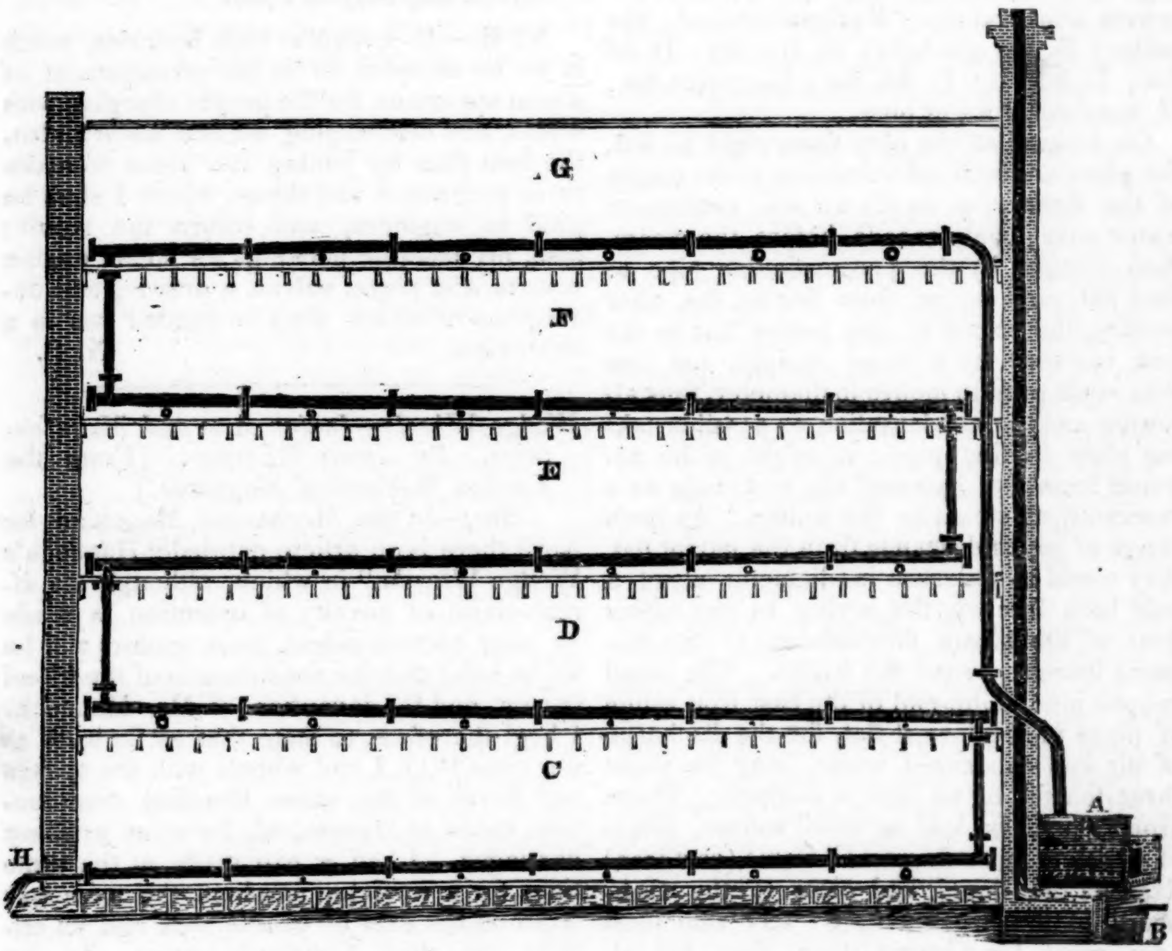
"He who conceals a useful truth is equally guilty with the propagator of an injurious untruth."—AUGUSTINE.



Effectual Plan of Heating Factories, &c., by Steam. Communicated by the INVENTOR. To the Editor of the Mechanics' Magazine and Register of Inventions, &c.

[We have much pleasure in inserting the following communication from Mr. SNODGRASS, an eminent engineer of Glasgow, N. Britain, now on a visit to the United States for the purpose of ascertaining the state of manufactures and mechanical inventions here. We hope to be favored with other contributions during his tour through various parts of the country, which, we are persuaded, will be highly interesting to our readers.—ED. M. M.]

SIR,—Having perused your interesting and valuable Magazine, I beg leave to avail myself of the pleasure of contributing in a small degree what appears to me would materially benefit the rising manufactories of this justly far-famed free country, namely, the best plan of heating by steam. Although I am almost a stranger here, I learn there are, and have seen, a number of beautiful factories heated by stoves, while in Great Britain there are none, to my knowledge, otherwise than by steam. It must be evident that this method is incompatible with the American atmosphere, which in particular seasons of the year, I am told, is highly electrical, and destitute of hydrogen. Stove heat must accelerate this evil in a considerable degree, in the apartments of the factories, which are

injurious to the staple of the cotton, during the process of roving and spinning, unhealthful to the workers, and a great increase of risk of accident from firing the building.

Having invented and introduced the system of heating by steam pipes, from 1799 to 1807, (see Philosophical Transactions, London, Vol. for March, 1807,) and since then having 27 years' experience, I presume to send you herewith a plain sketch of the simplest and most effectual plan of heating any regular built factory, and with steam of the lowest temperature. References—A, the boiler; B, the ash-hole; C, 1st flat; D, 2d flat; E, 3d flat; F, 4th flat; G, garret flat; H, condensed water pipe.

On looking at the plan from right to left, the pipes are inclined according to the length of the factory, so as the air and condensed water may freely recede before the steam, then descend by the perpendicular pipe to next flat, and so on from flat to flat, after sending the steam to the garret flat in the first instance by a large upright, not less than eight or nine inches in diameter, thus allowing as little condensation as possible taking place in that pipe; it ought to be secured from the external air, and made as a reservoir of steam to the boiler. As each range of pipes descends from the garret flat, they ought to increase in diameter about a half inch in each flat, owing to the latent heat of the steam diminishing as the distance increases from the boiler. The small copper pipe at the end of the cast iron range of pipes in the lowest flat, for the discharge of air and condensed water, may be about three-fourths of an inch in diameter. These pipes should be laid on small rollers, pivots of which to move in a small frame (cast iron) fixed on the floors, and close to the washboard of the apartment, on any side most convenient for passing them, thus, not almost, appearing in the room, and, in the lowest position, more effectually heating the air.

The data for proportioning the diameter of these pipes to the temperature of the air in the apartments is a square foot of surface of steam pipe for 200 cubic feet of air, to produce about 64 degrees of heat, supposing the steam about 4 lbs. on the square inch of pressure above the atmosphere, and the surface of the pipes black,—160 superficial inches steam pipe for 72 degrees of heat.

I may add: the boiler may be so placed that the condensed water may be returned to the bottom, and save in a small degree the latent heat therein. Where steam engines are employed to drive the machinery, the surplus steam for a great part of the year is sufficient to heat the factory, thus saving the whole expense of fuel nearly. Insurance ought not to be more than the half, compared with the risk of stoves. If any further information is found wanting, your taking the trouble of addressing me, care of Messrs. Thomson & MacFarlane, No. 87 Pearl street, will be duly attended to by,

Sir, yours, most respectfully,

Neil Snodgrass,
Civil Engineer, of Glasgow.

New-York, May 5, 1834.

N. B.—In irregular built factories, much is to be attended to in the arrangement of steam apparatus, for the proper charging with steam, and discharging air and water; also, the best plan for joining the pipes to make them permanent and cheap, which I shall be glad to engineer, and insure the result; also, my metallic packings for steam engine pistons, and piston valves, a drawing and description of which shall be handed you in a short time. N. S.

Wedge Wheels—Indian Arts and Manufactures. By John Robison. [From the London Mechanics' Magazine.]

Sir,—In the Mechanics' Magazine for April there is an article entitled "Hancock's Wedge Wheels," in which, although no direct claim of novelty of invention is made by your correspondent, most readers will be led to infer that the construction of the wheel is new, and the invention of Mr. Hancock. I beg, therefore, to state that as far back as the year 1811, I had wheels with the spokes and naves of the same identical construction, made at Hyderabad, for some artillery carriages. I had a pair made at the same time for a curricle, in which the nave was fixed on the axle by double nuts and an oil-tight cup, like Collinge's patent. In the putting together of these wheels, I used a precaution which appears to have escaped your correspondent. I made the butts of the spokes a little too full to admit of their touching the metal box, leaving a vacuity of near an eighth of an inch between them; a corresponding opening was left at the joints of the felloes, and the consequence was that on the tire hoop being put on, its contraction forced the spokes home to the box, and wedged them so hard together at the shoulder, that, even in the hot climate of India, I never observed a spoke become loose by shrinking; it need hardly be said, that the bolt-holes in the butts of the spokes require to be made of an oval form, to admit of the contraction taking place without bending the bolts. My naves were of gun-metal, and I

found it better to have the holes of the inner flanch tapped, than to have nuts on the bolts.

A construction very analogous to this has long been in use in the Madras Artillery, in which service I have always understood that it gave every satisfaction. I once witnessed a striking proof of its good qualities, in seeing a field-piece upset in the course of a charge over some rocky ground, and dragged some yards on its back, until it again righted, without any thing appearing to have given way; in such cases, when the wheel fails, the butts are all left firmly seated in their place, and the spokes break off near to the edges of the flanges.

I observe you have an Indian correspondent, who occasionally gives you descriptions of tools and practices in use among the native workmen. He has omitted to notice one which may be made useful in this country: the saw of an Indian workman always cuts in the pull, and not in the push; by this means a thin bladed saw may be made to do the work of a strong one, as no application of strength in pulling will cause it to buckle. If small saws, such as key-hole saws, were formed to cut by the pull, they would not be so liable to break as they are at present; and if saws for pruning fruit trees were so made, they might be fixed to the ends of long poles and worked from the ground, without requiring the use of a ladder. The common hand-saw in India is from 14 to 18 inches long, with a handle like that of a duelling pistol.

If you have the means of communicating with your Bombay correspondent, you should ask him to get you an account of the processes followed by the lapidaries of the north-west of India, where they make cups and other things of agates, at so cheap a rate, and yet so much cut, that they must have some expeditious methods which may be useful here if known.

I am, sir, your very obedient servant,

JOHN ROBISON.

9 Atholl Crescent, Edinburgh, March 14, 1834.

History of Chemistry. [Continued from page 216.]

OF TIN.—This is one of the metals which was earliest known, and of which the discovery must have been among the first which was made by men; at least, its discovery appears to be hidden in the darkness of ancient times, even beyond those of fabulous history. The Egyptians made great use of it in their arts, and the Greeks alloyed it with other metals. Pliny, without composing an accurate history, or precisely comparing its qualities with other metals, speaks of it as a metal well known, and much employed in the arts, and even applied to a great number of the ornaments of luxury. He often calls it white lead, and points out its frequent and fraudulent contamination with black lead, or lead properly so called.

The alchemists attended greatly to tin; they named it Jupiter, and have distinguished its various preparations by the name of Jovial.

Pure tin is of a white color, equal in beauty and brilliancy to that of silver; and if this color were not changeable, it would be as valuable as silver. It was formerly considered as the lightest of metals, when a distinct and particular class was made of the semi-metals. Its specific gravity varies from 7·291 to 7·500, according as it is hammered or not.

It is one of the softest of metals. It may be easily scratched with the nail; and there is scarcely any other metal which cannot injure its surface by pressure or by friction. A knife readily cuts it; it may be easily bended, and when bended affords a peculiar crackling noise. In this property it has been compared to zinc, but the noise is very different, or much weaker in zinc than in tin.

This phenomenon appears to depend on a separation of its parts, and the sudden fracture which they suffer by the bending, though tin is not easily broken. Its sonorous quality is feeble; its ductility is sufficient to admit of its being reduced by the hammer, or laminating cylinder, into very thin leaves, which are of great use in the arts. It holds the fifth rank among metals in this property. It has little elasticity or tenacity; a wire of this metal of one-tenth of an inch in diameter supports, without breaking, a weight of fifty pounds.

Tin is one of the most dilatable of metals by caloric, according to the experiments of Muschenbroeck.

It is also a good conductor of heat. After mercury, it is the most fusible of all the metals. It comes immediately before bismuth and lead in this respect; its melting point is 440° of Fahrenheit's scale. When fused it does not rise in vapor but at a very elevated temperature; it has ever been considered as one the most fixed of metals; on which account the alchemists thought it considerably resembled silver. If it be suffered to cool slowly, and when its surface is congealed it be pierced, and the part which is still fluid be carefully poured out, the interior presents crystals in rhombs of considerable size, formed by the assemblage of a great number of small needles longitudinally united.

Tin is a very good conductor of electrici-

ty and galvanism, and is frequently used for covering conductors, and for Leyden bottles. It has a very remarkable odor, with which it impregnates the hands and bodies rubbed with it. Its taste is also very sensible, and it also possesses very powerful medicinal properties.

Tin is not very abundant in the bowels of the earth, at least in Europe. The most abundant mines are in Cornwall, Bohemia, and Saxony. The most skilful mineralogists have hitherto distinguished only three species of tin ores: namely, native tin, its oxide, and its sulphuretted oxide.

Tin is not easily oxidized in the air without heat, but it soon loses its bright and beautiful white color. When cut, it is as brilliant and as clear as silver; but in a few hours this fine color changes, becomes dull, and in a few days becomes tarnished. Long exposure to the air considerably increases this alteration, though it takes place only at the surface, so that at last it becomes of a dirty grey, without any brilliancy, and is covered with a light stratum of grey oxide. It is, therefore, necessary that vessels of tin should be frequently cleaned and brightened to renew their surface and retain their beauty. But this weak oxidation never penetrates so deeply as to justify the assertion that tin, like other metals, rusts in the air. When tin is fused with the contact of the air, the metal, when scarcely liquified, becomes covered with a dull grey pellicle, which becomes wrinkled, and separates from the portion of fused tin. When this pellicle is detached, another is formed; and by proceeding in the same manner, the whole of the tin may be converted into pellicles.

In the art of casting and purifying tin vessels, this oxidized matter formed at the surface of the metal in fusion was called dross; and it is very evident that it is in the power of the founder to convert all the tin into dross; he consequently did not lose this pretended impurity, but knew very well how to recover it again in its metallic form, by heating it with tallow or resin. This crust is therefore a true grey oxide of tin; the metal contains from eight to ten per cent. of oxygen, and it is easily reduced. If tin be continually heated with the contact of air, particularly with agitation, it becomes divided, attenuated, and is changed into a powder, which gradually becomes white, with increase of weight, is more oxidized, and constitutes what is called putty of tin in the arts.

Of Lead. — The Alchemists compared lead to Saturn, not only because they suppose this metal to be the oldest, and, as it were, the father of all the others, but also because it was considered as very cold, and possessing the property of absorbing and apparently destroying almost all the other metals; in the same manner as fabulous history affirms that Saturn, the father of the gods, devoured his children.

Lead is of a blueish white color, and when newly melted is very bright, but it soon becomes tarnished by exposure to the air. It has scarcely any taste, but emits on friction a peculiar smell. It stains paper, or the fingers, of a blueish color. When taken internally it acts as a poison.

Its specific gravity is 11·3523, but it is not increased by hammering; so far from it, that Muschenbroeck found lead when drawn out into a wire, or long hammered, to be diminished in its specific gravity. A specimen, at first of the specific gravity 11·479, being drawn out into a fine wire, was of the specific gravity 11·317; and on being hammered it became 11·2187; yet its tenacity was nearly tripled.

It is very malleable, and may be reduced to very thin plates by the hammer; it may be also drawn out into a wire, but its ductility is not great. Its tenacity is such that a lead wire, one-tenth of an inch in diameter, is capable of supporting only 29¼ pounds without breaking.

Lead is a very good conductor of caloric, though it is not extremely dilatable. It melts at a low heat, and immediately after mercury, tin, and bismuth; it holds the fourth rank in the order of fusibility. Mr. Crichton, of Glasgow, estimates it at 612 degrees of Fahrenheit's thermometer. When it is kept long red hot, it sublimes, and emits fumes in the air; but for this purpose a very elevated temperature is required. If it be slowly cooled, it crystalizes in quadrangular pyramids, all formed, as it would appear, of octahedrons. Thus it was that Mongez, the younger, obtained it. It is observable that when this operation is performed, it succeeds best (as tin likewise does) when the lead has been fused several times successively.

This metal is a conductor of electricity and galvanism; but it appears that it possesses these properties only in a weak degree. It has a particular and rather fetid smell; its taste is also somewhat acrid and disagreeable; in consequence of this property it would seem that it acts upon the animal economy, and produces the deadening and paralyzing action which is so well known.

The ores of lead are very abundant in nature, particularly in France, Germany, England, &c. It is also a metal of which the ores are the most varied.

The treatment of the ores of lead in the large way is one of the most important of metallurgical operations, and one of those which have the greatest as well as the most intimate connection with the knowledge and accurate processes of Chemistry. The sulphurous ores containing silver are wrought by pounding them in a stamping engine, and carefully washing them on platforms, and then carrying them to the blast-furnace, where they are first roasted by a gentle heat and afterwards fused by increase of temperature. The fused lead is drawn off from the furnace by opening a hole on one of the sides of its hearth, which, during the fusion, is kept closed with loam. The lead is first cast into pigs, which are called work-lead, because it is intended to be used in subsequent operations to separate the silver which it contains.

Lead exposed to the air becomes speedily tarnished, soon loses the slight brilliancy which characterizes it, becomes of a dirty grey color, and afterwards of a light grey, which constitutes a true rust at its surface.

When thin plates of lead are exposed to the vapor of warm vinegar, they are gradually corroded, and converted into a heavy white powder, used as a paint, and called *white lead.* This powder was formerly considered to be a peculiar oxide of lead, but it is now known that it is a compound of the yellow oxide and carbonic acid.

The grey oxide of lead, when strongly heated for a considerable time in contact with the air, soon becomes yellow by a new absorption of oxygen. In this state of yellow oxide it is called *massicot* in the arts; it appears that it contains from six to nine parts of oxygen in the hundred. It is distinguished into two kinds in commerce on account of its color: the one is called *white massicot*, and the other *yellow massicot.* It is a pigment of a dull hue, without any beauty; sometimes inclining to green, which nevertheless is prepared in the large way in certain manufactories, on account of the uses to which it is applied in the arts. The method of producing it consists simply in perpetually agitating the lead in contact with the air, without using a violent heat.

If massicot, ground to a fine powder, be put into a furnace, and constantly stirred while the flame of the burning coals plays against its surface, in about 48 hours it is converted into a beautiful red powder, known by the name of *minium*, or *red lead.* This powder, which is likewise used as a paint, and for various other purposes, is the *tritoxide*, or *red oxide of lead.*

Lead and tin may be combined in any proportion by fusion. This alloy is harder and possesses much more tenacity than tin. Muschenbroeck informs us that these qualities are a maximum when the alloy is composed of three parts of tin and one of lead. The increased hardness seems to prevent in a great measure the noxious qualities of the lead from becoming sensible when food is dressed in vessels of this mixture. What is called *ley pewter* in this country is often scarcely any thing else than this alloy.* *Tinfoil* is also a compound of tin and lead.

Of Nickel.—Hierne was the first person who mentioned the particular ore which contains nickel, in a work on the art of discovering metals, published in 1694. The ore was named kupfernickel by the Germans, which signifies false copper. Henckel considered it as a species of cobalt, or arsenic, mixed with copper. Cramer referred it also to the copper and arsenical ores, though he did not obtain copper from it, which is also confessed by Henckel.

In its highest state of purity it is of a yellowish or reddish white, of variable brilliancy and granulated texture. This texture is lamellated only in the case of impurity.

Its specific gravity, according to Richter, after being melted, is 8·279; but when hammered it becomes 8·666.

It is malleable both cold and hot, and may without difficulty be hammered out into plates not exceeding the hundredth part of an inch in thickness.

It is attracted by the magnet at least as strongly as iron. Like that metal it may be converted into a magnet, and in that state points to the north, when freely suspended, in the same manner as a common magnetic needle.

There are three ores of nickel, very distinct and very easy to be distinguished; these are the sulphuret of nickel, ferruginous nickel, and native oxide of nickel.

Rinman also affirms that nickel has been found a native of Hesse; it is heavy, of a deep red, forming a kind of product of the furnaces among the materials from which nickel may be extracted. It is considered as an alloy of cobalt and bismuth by the medium of nickel. Nickel is very difficult to be oxidized by the action of caloric and of the air. When it is heated under a muffle, and constantly agitated, it only assumes a dark color. However, by long exposure to moist and cold air, it becomes covered

* There are three kinds of pewter in common use in this country, namely, plate, trifle, and ley. The plate pewter is used for plates and dishes; the trifle chiefly for pint and quart pots; and the ley metal for wine measures, &c. Their specific gravities are as follows: plate, 7·248; trifle, 7·359; ley, 7·963.

with an efflorescence of a clear green color, of a very particular and distinct tinge. It is this efflorescence which is found upon the surface of the sulphurous ores of nickel, the tinge of which being very remarkable, and very different from that of copper, enables us to distinguish them with ease and certainty.

The alloys of this metal are but very imperfectly known.

Mr. Hatchett melted a mixture of 11 parts gold and one nickel, and obtained an alloy of the color of fine brass. It was brittle, and broke with a coarse-grained earthy fracture. The specific gravity of the gold was 19·172; of the nickel 7·8; that of the alloy 17·068. The bulk of the metals before fusion was 2792, after fusion 2812; hence they suffered an expansion. Had their bulk before fusion been 1000, after fusion it would have become 1007. When the proportion of nickel is diminished, and copper substituted for it, the brittleness of the alloy gradually diminishes, and its color approaches to that of gold. The expansion, as was to be expected, increases with the proportion of copper introduced.

Nickel has hitherto been applied to little or no use. It cannot, however, be doubted, that it may be employed with great advantage in the manufacture of enamels, glass, porcelain, and pottery. It is even probable, that it may be an ingredient in the secret processes of some manufactures, as large portions of it are frequently found with the druggists of Paris, who procure it from Saxony only in proportion to the demand which is made for it.

Of Cadmium.—Cadmium was first discovered by M. Stromeyer, in the autumn of 1817, in carbonate of zinc, which he was examining in Hanover. It has been since found in the Derbyshire silicates of zinc. The following is Dr. Wollaston's process of procuring cadmium. From the solution of the salt of zinc supposed to contain cadmium, precipitate all the other metallic impurities by iron; filter and immerse a cylinder of zinc into the clear solution. If cadmium be present it will be thrown down in the metallic state, and when re-dissolved in muriatic acid will exhibit its peculiar character on the application of the proper tests. The color of cadmium is a fine white, with a slight shade of blueish grey, approaching much to that of tin, which it resembles in lustre and susceptibility of polish. Its texture is compact, and its fracture hackly. It crystalizes easily in octahedrons, and presents on its surface, when cooling, the appearance of leaves of fern. It is flexible, and yields readily to the knife. It is harder and more tenacious than tin; and, like it, stains paper, or the fingers. It is ductile and malleable, but when long hammered it scales off in different places. Its specific gravity, before hammering, is 8·6, and when hammered it is 8.69. It melts and is volatilized under a red heat. Its vapor, which has no smell, may be condensed in drops like mercury, which, on congealing, present distinct traces of crystalization.

Cadmium is as little altered by exposure to the air as tin. When heated in the open air it burns like that metal, passing into a smoke which falls and forms a very fixed oxide, of a brownish yellow color. Nitric acid readily dissolves it cold; diluted sulphuric, muriatic, and even acetic acids, act feebly on it with the disengagement of hydrogen. The solutions are colorless, and are not precipitated by water.

Cadmium unites easily with most of the metals, when heated along with them and the air excluded; but most of its alloys are brittle, and without color. That of copper and cadmium is white, with a slight tinge of yellow. Its texture is composed of very fine plates. A very small portion of cadmium communicates a good deal of brittleness to copper; but at a strong heat cadmium flies off.

Cadmium unites with several other metals, particularly with cobalt, platinum, and mercury. With the last metal it forms an amalgam, the specific gravity of which exceeds that of mercury itself.

Of Zinc.—It is believed that zinc was not known to the ancients. Paracelsus is the first chemist who has treated of it, and who gave it the name which it bears. Agricola has since termed it *contre-feyne*, and Boyle, *speltrum*. Albertus Magnus, who died in the year 1280, makes very distinct mention of it; he knew that it was combustible and inflammable, and that it colored metals. It appears that zinc has for a long period back been extracted from its ores in the East Indies, as was first discovered by Jungius, in the year 1647. It was brought from those parts under the name of *tutenague*. Without being particularly acquainted with it, and distinguishing it accurately from other metals, the Greeks seem also to have employed it, as it is said to have constituted a part of the famous Corinthian brass.

It is not known by what process the Chinese obtain this metal, which they employ in a great number of alloys; it is, however, believed that they extract it by distillation. Henckel asserted, in 1721, in his Pyritolo-

gia, that zinc might be extracted from calamine.

Zinc is of a brilliant white color, with a shade of blue, and is composed of a number of thin plates adhering together. When this metal is rubbed for some time between the fingers, they acquire a peculiar taste, and emit a very perceptible smell. When rubbed upon the fingers, it tinges them of a black color. The specific gravity of melted zinc varies from 6·861 to 7·1; the lightest being esteemed the purest. When hammered, it becomes as high as 7·1908.

This metal forms, as it were, the limit between the brittle and the malleable metals. When struck with a hammer it does not break, but yields, and becomes somewhat flatter; and by a cautious and equal pressure, it may be reduced to pretty thin plates, which are supple and elastic, but cannot be folded without breaking. This property of zinc was first ascertained by Mr. Sage. When heated somewhat above 212° it becomes very malleable. It may be beat at pleasure without breaking, and hammered out into thin plates. When carefully annealed it may be passed through rollers. It may also be very readily turned on the lathe. When heated to about 400° it becomes so brittle that it may be reduced to powder in a mortar.

It possesses a certain degree of ductility, and may with care be drawn out into wire. Its tenacity, from the experiments of Muschenbroeck, is such that a wire, whose diameter is equal to one-tenth of an inch, is capable of supporting a weight of about 26 pounds.

When heated to the temperature of about 680° it melts; and if the heat be increased it evaporates, and may be easily distilled over in close vessels. When allowed to cool slowly it crystalizes in small bundles of quadrangular prisms, disposed in all directions. If they are exposed to the air whilst hot, they assume a blue changeable color.

Zinc is applied to uses no less numerous than important in many of the arts. It forms a part of a number of hard and white alloys. It is particularly employed in the fabrication of tombac and brass. The eastern nations, and especially the Chinese, make use of it, as has already been observed, much more frequently than the Europeans; perhaps because they possess it in greater abundance than we do, and perhaps because they are better acquainted with its useful properties.

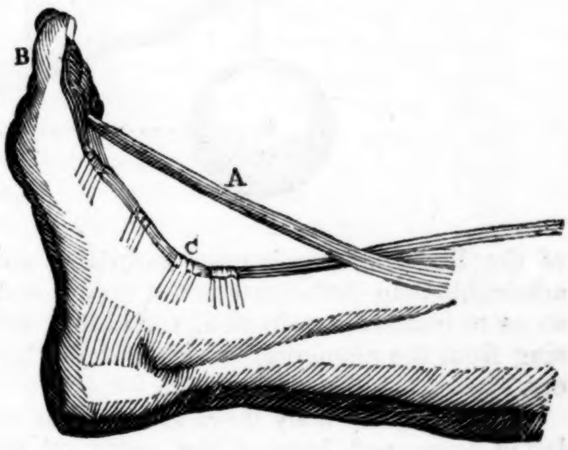
Zinc and its chemical preparations have already been applied to medicinal purposes. Its property of conducting so great a degree of galvanism may hereafter render it much more valuable to the healing art.

Animal Mechanics, or Proofs of Design in the Animal Frame. [From the Library of Useful Knowledge.]

(Continued from page 221.)

We may perceive the same effect to result from the course of the tendons, and their confinement in sheaths, strengthened by cross straps of ligament. If the tendon, A, (fig. 27) took the shortest course to its ter-

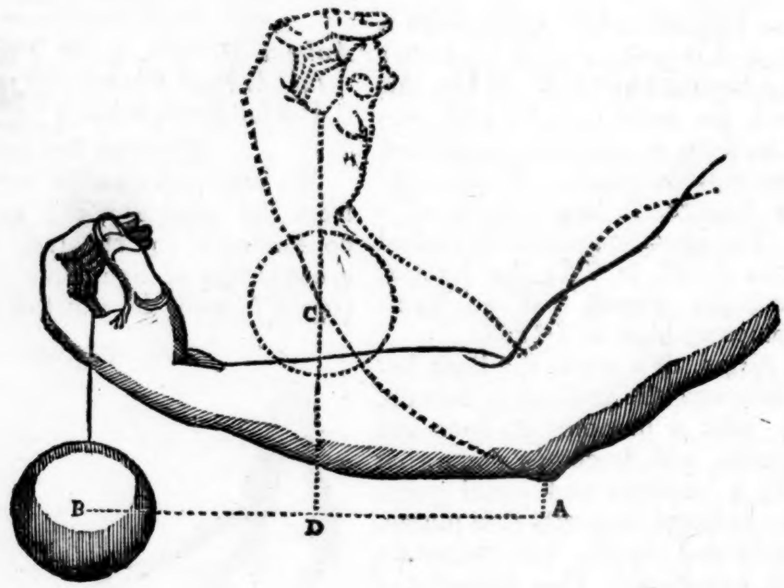
Fig. 27.



mination at B, it would draw up the toe with greater force; but then the toe would lose its velocity of movement. By taking the direction, C, close to the joints, the velocity of motion is secured, and by this arrangement the toes possess their spring, and the fingers their lively movements. We may take this opportunity of noticing how the mechanical opposition is diminished as the living muscular power is exhausted. For example, in lifting a weight, the length of the lever of resistance will be from the centre of the elbow joint, A, (see engraving on the following page, fig. 28,) to the centre of the weight B. As the muscles of the arm contract, they lose something of their power; but in a greater proportion is the mechanical resistance diminished, for when the weight is raised to C A D, it becomes the measure of the lever of resistance.

A more admirable thing is witnessed by the anatomist—we mean the manner in which the lever, rising or falling, is carried beyond the sphere of action of one class of muscles, and enters the sphere of activity of others. And this adaptation of the organs of motion is finely adjusted to the mechanical resistance which may arise from the form or motion of the bones. In short, whether we contemplate the million of fibres which constitute one muscle, or the many muscles which combine to the movement

Fig. 28.



of the limb, nothing is more surprising and admirable than the adjustment of their power so as to balance mechanical resistance, arising from the change of position of the levers.

In the animal body there is a perfect relation preserved betwixt the parts of the same organ. The muscular fibres forming what is termed the belly of the muscle, and the tendon through which the muscle pulls, are two parts of one organ; and the condition of the tendon indicates the state of the muscle. Thus jockeys discover the qualities of a horse by its sinews or tendons. The most approved form in the leg of the hunter, or hackney, is that in which three convexities can be distinguished,—the bone, the prominence of the elastic ligament behind the bone, and behind that the flexor tendons, large, round, and strong. Strong tendons are provided for strong muscles, and the size of these indicate the muscular strength. Such muscles, being powerful flexors, cause high and round action, and such horses are safe to ride; their feet are generally preserved good, owing to the pressure they sustain from their high action. But this excellence in a horse will not make him a favorite at Newmarket. The circular motion cannot be the swiftest; a blood horse carries his foot near the ground. The speed of a horse depends on the strength of his loins and hind quarters; and what is required in the fore-legs is strength of the extensor tendons, so that the feet may be well thrown out before, for if these tendons be not strong, the joints will be unable to sustain the weight of his body when powerfully thrown forward, by the exertion of his hind quarters, and he will be apt to come with his nose to the ground.

The whole apparatus of bones and joints being thus originally constituted by Nature in accurate relation to the muscular powers, we have next to observe that this apparatus is preserved perfect by exercise. The tendons, the sheaths in which they run, the cross ligaments by which they are restrained, and the *bursæ mucosæ** which are interposed to diminish friction, can be seen in perfection only when the animal machinery has been kept in full activity. In inflammation and pain, and necessary restraint, they become weak; and even confinement, and want of exercise, without disease, will produce imperfections. Exercise unfolds the muscular system, producing a full bold outline of the limbs, at the same time that the joints are knit, small, and clean. In the loins, thighs, and legs of a dancer, we see the muscular system fully developed; and when we turn our attention to his puny and disproportioned arms we acknowledge the cause—that in the one instance exercise has produced perfection, and that, in the other, the want of it has occasioned deformity. Look to the legs of a poor Irishman travelling to the harvest with bare feet: the thickness and roundness of the calf show that the foot and toes are free to permit the exercise of the muscles of the leg. Look again to the leg of our English peasant, whose foot and ankle are tightly laced in a shoe, with a wooden sole, and you will perceive, from

* These *bursæ mucosæ* (mucous purses) are sacks containing a lubricating fluid. They are interposed wherever there is much pressure or friction, and answer all the purposes of friction wheels in machinery.

the manner in which he lifts his legs, that the play of the ankle, foot, and toes, are lost, as much as if he went on stilts, and therefore are his legs small and shapeless.

And this brings us naturally to a subject of some interest at present: we mean the new fashion of exercising our youth in a manner which is to supersede dancing, fencing, boxing, rowing, and cricket, and the natural impulse of youth to activity.

By this fashion of training to what are termed *gymnastics*, children at school are to be urged to feats of strength and activity, not restrained by parental authority, nor left to their own sense of pleasurable exertion. They are made to climb, to throw their limbs over a bar, to press their feet close to their hip, their knees close to their stomach; to hang by the arms and raise the body; to hang by the feet and knees; to struggle against each other by placing the soles of their feet in opposition, and to pull with their hands. No doubt if such exercises be presevered in the muscular powers will be strongly developed. But the first question to be considered is the safety of this practice. We have seen a professor of gymnastics, by such training, acquire great strength and prominence of muscles; but by this unnatural increase of muscular power, through the exercise he recommended, he became ruptured on both sides. The same accident has happened to boys too suddenly put on these efforts.

It is proper to observe, that when the muscular power is thus, we may say preternaturally increased, whether in the instance of a race-horse, an opera-dancer, or a pupil of the Calisthenic school, it is not merely necessary to put them on their exercises gradually in each successive lesson, but each day's exertion must be preceded by a wearisome preparation. In the great schools, like that at Stockholm, the master makes the boys walk in a circle; then run, at first gently; and so he gradually brings them into heat, and the textures of their frame are composed to that state of elasticity and equal resistance, as well as to vital energy, which is necessary for the safe display of the greater feats of strength and activity. This caution in the public exercises is the very demonstration of the dangers of the system. The boys will not be always under this severe control, and yet it is important to their safety.

We may learn how necessary it is to bring the animal system gradually into action from the effects of very moderate exercise on a horse just out of the dealer's hands. The purchaser thinks he may safely drive him ten miles, not aware that the horse has not moved a mile in a week, and the consequence is inflammation and congestion in his lungs. The regulation in the army has been made on a knowledge of these facts. When young horses are brought from the dealer they are ordered to be walked an hour a day the first week, two hours a day the second week, three hours a day in the third week. They are to be fatigued by walking, but they must not be sweated in their exercise. Horses for the turf, under three years old, in training for the Derby, are brought very slowly to their exercise, beginning with the lounge; then a very light weight is put upon them, and that gradually increased. Indeed, nothing can better show the effects of exercise in perfecting the muscular action than the consequence of the loss of one day's training. It will bring the favorite to the bottom of the list, and that without any suspicion of lameness; but from a knowledge of the fact, that even such a slight irregularity in his training will have a sensible effect on his speed. Shall the possibility of pecuniary loss excite the jockey to more care for his horse than we, in our rational and humane attention to the education of our youth, pay to their health and safety?

In reflecting on these many proofs of design in the animal body, it must excite our surprize, that anatomy is so little cultivated by men of science. We crowd to see a piece of machinery, or a new engine, but neglect to raise the covering which would display in the body the most striking proofs of design, surpassing all art in simplicity and effectiveness, and without any thing useless or superfluous.

A more important deduction from the view of the animal structure is, that our conceptions of the perfection and beauty in the design of nature are exactly in proportion to the extent of our capacity. We are familiar with the mechanical powers, and we recognize the principles in the structure of the animal machine; and, in proportion as we understand the principles of hydrostatics and hydraulics, are able to discern the most beautiful adaptation of them in the vessels of an animal body. But when, to our further progress in anatomy, it is necessary that we should study a matter so difficult as the theory of life, imperfect principles or wrong conceptions distort and obscure the appearances: false and presumptuous theories are formed, or we are thrown back in disappointment into scepticism, as if chance only could produce that of which we do not comprehend the perfect arrangement. But studies better directed, and prosecuted in a better spi-

rit, prove that the human body, though deprived of what gave it sense and motion, is still a plan drawn in perfect wisdom.

A man possessed of that humility which is akin to true knowledge, may be depressed by too extensive a survey of the frame of nature. The stupendous changes which the geologist surveys—the incomprehensible magnitude of the heavenly bodies moving in infinite space, bring down his thoughts to a painful sense of his own littleness: "to him, the earth with men upon it will not seem much other than an ant hill, where some ants carry corn, and some carry their young, and some go empty, and all to and fro a little heap of dust."*

He is afraid to think himself an object of Divine care; but when he regards the structure of his own body, he learns to consider space and magnitude as nothing to a Creator. He finds that the living being which he was about to contemn, in comparison with the great system of the universe, exists by the continuance of a power no less admirable than that which rules the heavenly bodies; he sees that there is a revolution, a circle of motions, no less wonderful in his own frame, in the microcosm of man's body, than in the planetary system; that there is not a globule of blood which circulates but possesses attraction as incomprehensible and wonderful as that which retains the planets in their orbits.

The economy of the animal body, as the economy of the universe, is sufficiently known to us to compel us to acknowledge an Almighty Power in the creation. What would be the consequence of a further insight—whether it would conduce to our peace or happiness, whether it would assist us in our duties, or divert us from the performance of them,—is very uncertain.

CHAPTER VII.

Books referring to these Subjects more generally.—Ray, "On the Wisdom of God manifested in the Works of the Creation," has several chapters on the animal economy.

Archdeacon Paley has composed a work of high interest, by taking the common anatomical demonstrations, and presenting them in an elegant and popular form. His work is entitled Natural Theology; or Evidences of the Existence and Attributes of the Deity, collected from the Appearances of Nature.

The celebrated Fenelon has, with the same pious object, composed a small duodecimo, in which he draws his arguments from the structure of animal bodies.

Wollaston, in the "Religion of Nature delineated," has the same train of reflection to prove that there can be no such thing as chance operating in and about what we see or feel; and he says, with great propriety, "How may a man qualify himself so as to be able to judge of the religions professed in the world; to settle his own opinions in disputable matters; and then to enjoy tranquillity of mind, neither disturbing others, nor being disturbed at what passes among them?"

Derham, in sixteen sermons, preached in 1711, at the lecture founded by Mr. Boyle, treats at length of the structure of our organs. These are also published separately under the title of *Physico-Theology;* and they naturally suggest to learned divines the expediency of sometimes expounding to their hearers the evidences of design apparent in the universe, as a sure means of enlightening their understandings, elevating their views, and awakening their piety.

This cultivation of the mind, by exercising it upon the study of proper objects, is a man's first duty to himself. Without it he can have no steady opinion on points of the nearest concern. He is wrought upon by circumstances which ought not to sway the mind of a sensible man; at one time depressed to the depths of despondency, and at another exalted into unreasonable enthusiasm. Without such cultivation, were a man to live a hundred years, he is at last like one cut off in infancy.

PART II.

Showing the Application of the Living Forces.

Amongst the least informed people, and in remote villages, there are old laws and rules regarding health, sickness, and wounds, which might be thought to come from mere experience; but they are, on the contrary, for the most part, the remains of forgotten theories and opinions, laid down by the learned of former days. Portions of knowledge, it would appear, confined at first to a select part of society, are in the progress of time diffused generally, and may be recognized in the aphorisms of the poor. These are traced to their source only by the curious few, who like to read old books, and to observe how that which is originally right, becomes, through prejudice and ignorance, distorted and fantastical.

If a very little exact knowledge of the structure of our own frames were more generally diffused, charity would be advanced,

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* Bacon.

empirics could hardly maintain their influence, and medical men might have a further motive to desire professional eminence.

Men suppose that the knowledge of their own bodies must be a science locked up from them, because of the language in which it is conveyed; or they take away their thoughts from it, as from the contemplation of danger, unwilling to survey the slight ties by which they hold their lives. They are like persons for the first time at sea, who shudder to calculate how many circumstances must concur to speed the frail vessel on its voyage, and how little is between them and the deep. It is then a mean and timid spirit that shuts out from our contemplation the finest proofs of Divine Providence. Galen's treatise on the uses of the parts of the human body was composed as a hymn to the Creator, and abounds in demonstrations of a Supreme Cause; and when Cicero desires to prove the existence of the Deity from the order and beauty of the universe, he surveys the body of man, deeming nothing more godlike, as marking man's superiority to the brutes, than the privilege of contemplating his own condition, since it teaches him the ways of Providence, from a knowledge of which come piety and all the virtues.

Although we are writing under the title of Animal Mechanics, the reader must be aware that we cannot proceed much farther on mechanical principles alone. At least, before we have it in our power to illustrate particular parts of the animal frame by reference to those principles, we must have the proofs before us that we are considering a living body. It is the principle of *life* which distinguishes the studies of the physiologist from the other branches of natural knowledge. To lose sight of this distinction is to tread back the path, and to engage once more in the vain endeavor to explain the phenomena of life on mechanical principles. We have taken mechanics in their application to mechanical structure in the living body, because they give obvious proofs of design, and in a manner that admits of no cavil. Yet, although those proofs are very clear in themselves, they are not so well calculated to warm and exalt our sentiments as these which we have now to offer, in taking a wider view of the animal economy.

In entering on the second department of this treatise, the reader may be startled at the subjects of discussion, but this comes also from ignorance of their nature. Much may be learned from the observation of things familiar. Their perpetual recurrence banishes reflection respecting them, but it is the business of philosophy to make us alive to the importance of that which we have been accustomed to from childhood, and have therefore long ceased to observe with attention.

In the first chapter of this second part we shall continue to examine the operations of the animal body, independently of the agency of the living property: we shall consider it as a mere hydraulic machine. Following the blood in its circle through cisterns and conduit pipes, we shall point out the application of the principles of this science, as we formerly did those of mechanics, and so arrive at the like conclusions by a different course. And as we before found every muscular fibre adjusted with mechanical precision, so now we shall find every branch of an artery, or of a vein, taking that precise course and direction which the experience of the engineer shows to be necessary in laying the pipes of an engine.

Having thus surveyed the mechanical operations of the animal body, and the course of the fluids conveyed through it, on hydraulic principles, we shall consider ourselves as having advanced through the meaner to the higher objects of inquiry, and proceed to show how the principle of life bestows different endowments on the frame-work; how motion originates in a manner quite different from that produced by mechanical forces; how the sensibilities animate the living properties of action; how the different endowments of life correspond with each other, and exhibit power and design in a degree far superior to any thing that we observed in the mechanical adjustment of the parts or the circulation of the fluids.

CHAPTER I.

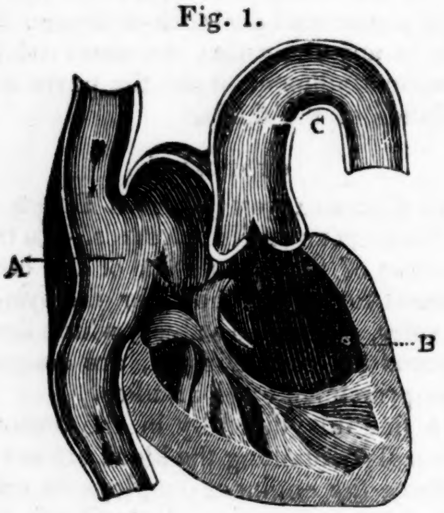
THE CIRCULATION OF THE BLOOD UPON THE PRINCIPLES OF HYDRAULICS.—In tracing the course of the circulation of the blood, it is natural to inquire how far the system of reservoirs, pipes and valves, which form the apparatus for conveying it, are constructed on the principles of hydraulics.

We find this difficulty in the outset, that the vessels containing the blood are not rigid, like those the engineer employs in erecting hydraulic machinery. Instead of resembling pipes which convey water, and which receive the force of gravitation on them, they have both elasticity and an appropriate living power. The artery, the tube which conveys the blood out from the heart to the body, has a property of action in itself. Its elasticity and muscular power must derange those influences which we study in pure hydraulics.

There is to be found, notwithstanding, a great deal that is common to both, when we compare the tubes of an animal body with the hydraulic engine; the capacity of the vessels; the increase or diminution of their calibres; their curves; the direction of their branches—all these ought still to be on the same principles on which experience has taught men to form conduit pipes. We ought not to be indifferent to these proofs of design, because we acknowledge that an infinitely superior power is brought into operation in the animal body, and which is necessary to the circulation of the blood. It renders the inquiry more difficult, but it does not obscure the inferences drawn from the consideration of the whole subject.

We shall first present to our readers the simplest form of the heart. It is not necessary to detail the more complicated structure of the human heart, where, in fact, two hearts are combined; the fibres of the one continued into the fibres of the other, and the tubes twisting round one another so as to present the form which is familiar to every body. Although there are four intricate cavities, seven tubes conveying the blood into them, and two conveying it out of them, we shall, for the purpose of considering the forces circulating the blood, and comparing the living vessels with pipes, present the heart and vessels as simple; yet with perfect truth, being, in fact, the heart and vessels of animals of more simple structure.

Fig. 1.



The action of the heart is this: the blood returns from the body by veins into the sinus, or auricle,* A, and distends it; this sinus is surrounded with muscular fibres; by the distention or elongation of these fibres they are excited, and the sinus contracts and propels the blood into the ventricle B. The ventricle is, more muscular; it is, in fact a powerful hollow muscle; it is excited by the distention, and contracts and propels the blood into the artery, C.

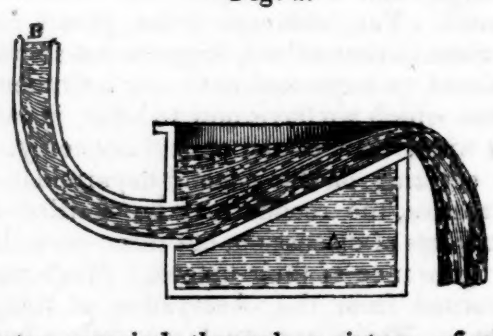
We understand, then, that every heart must, at least, consist of two cavities alternating in their action; that the vessel which carries the blood to them is called a vein; and that the vessel which carries the blood out from them is the artery.

The first thing that strikes a person examining the heart is the extraordinary intricacy of the cavities, from the interlacing of its muscular fibres, and he naturally says that they appear ill calculated for conveying a fluid through them. There is an attraction between fluids and solids, he might observe, and this attraction is increased by the extension of the surfaces of the pillars and cords which he sees in the interior of the heart.

We must remind him that the blood is coming back from the body, having performed very different offices, in different parts, and has parted with different properties in the several organs it has supplied. There is, in that stream of blood which enters through the vein, a new supply of fluid, which has come by digestion, the material for making fresh blood, as well as that which has run the circle. These two fluids must be thoroughly mixed together, and no doubt this is one of the offices provided for by the intricacy of the interior of the heart.

Again, looking to the recesses of the cavities formed between the fleshy columns, and behind the valves, we might suppose that the blood would remain there stagnant. There are cavities, or recesses, too, in the remote parts of the circulating vessels, where we might suspect that the influence of the stream would not be felt, and a stagnation might take place. But there is attraction between the particles of fluids, as well as between the fluids and their containing tubes. Let us see then how, in this figure, a stream of

Fig. 2.



water, carried through a cistern of water, will, by its friction, draw after it the water in

* Auricle, from *auricula*, the flap of the ear, is a name given to the sinus, because a corner of it hangs over like a dog's ear.

the cistern, and carry it above its natural level, and over the side of the vessel.

The stream entering the reservoir, A, by the pipe, B, carries with it all the water, C, which stands above the level of its upper surface. By this we see that the stream of blood entering into the heart, even if its cavities were not emptied at each impulse, as some contend they are, would draw out the blood from its recesses, so that no part could remain stagnant, but, on the contrary, all would be carried in eddies round the irregularities, until they took the direction of the great artery, in which they would be perfecly combined.

The next thing to be noticed partakes of the nature of a mechanical provision—we mean the action of the valves.

We must here remark, that the opening into the ventricle is very different from that which leads out of it, the latter being much smaller. Medical writers describe this as if it were nothing to them, and a mere accident. But it must be recollected that a stream of water entering a reservoir is in a very different condition from that which is going out of it; it is on this principle that the mouths (*ostia* is the anatomical term) of the ventricle are differently formed, and it is this difference which makes the structure of the valves which guard those passages so dissimilar and so appropriate. Without attention to this we should follow our medical authorities, and call this variety in the mechanical adaptation a mere playfulness in nature. It is more agreeable to us to see a precision of design visible at the first step of this inquiry.

The valves of the heart are regular floodgates, which close the openings against the retrograde motions of the blood. They are not all of the same mechanical construction, and their difference deserves the reader's attention as proving design in this hydraulic machinery.

The valve which we have first to describe closes the opening betwixt the auricle, or sinus, and the ventricle, and prevents the action of the ventricle propelling the blood back again into the auricle.

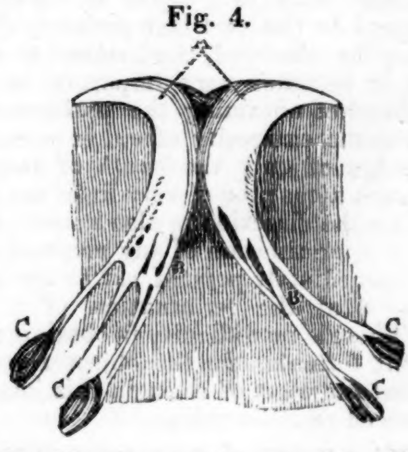
It is a web, or membrane, resembling a sail when bagged by the wind. The blood catches the margin of this membrane, and distends it as the wind does the stay-sail, or gib, of a vessel, which it much resembles, being triangular and pointed. There are three of these membranes, and the valve is called *tricuspid*, or three-pointed. Three membranes, then, of this kind, combining and being floated back upon the mouth of the opening, effectually close it.

The illustration of the action of these valves by a sail is so perfect, that if the reader will have patience to attend to those little contrivances which the mariner finds necessary for strengthening his canvass, and giving to it the full influence of the wind, he will have an accurate idea of the adjustment of these floating valves.

Fig. 3.

To carry on the comparison: one edge of the stay-sail is extended upon the stay, A A, and tied to it by *hanks*. The edges of the sails, called the *leeches*, have a *bolt-rope* run along them; and on the edge where it is attached, the canvass is strengthened by being hemmed down or tabled. In the same way as the foot of the sail, or lower margin, is strengthened with the bolt-rope, just so are the valves strengthened at their edges and their corners. Where the two ropes join in the loose corner of the sail, they form a clue—a loop to which tackle is attached; the valve has such a corner so strengthened, and has a cord attached. The corners of the sail are strengthened by additional portions of canvass called patches; so are the valves strengthened where their tendons are

Fig. 4.



infixed. To the corner or clue, B, ropes are attached which are called the *sheets*, C C. These being drawn tight, spread out

the foot of the sail to one side or the other, according to the direction of the wind, and the tack the ship is on; the valves have also their tackle; and, in short, we shall find a resemblance to all the parts of a sail in the valves of the heart.

One edge of the triangular valve is tied to the margin of the opening, as one of the leeches of the sail is attached to the stay; the opposite corner is loose, and floats, as the sail does in tacking, until the blood, bearing against it as the wind bears against the sail, bags and distends it; the corner is then held down by tendons, for there are cords attached to the corner of the valve, as well as to the corner of the sail. These the anatomists call *cordæ tendineæ*, B B, which in their office have an exact resemblance to the ropes called the sheets of the sail. They are delicate tendons attached to the margin of the valve, and they prevent the margin from being carried back into the auricle.

On the Location of Railroad Curvatures. By VAN DE GRAAFF. [From the American Railroad Journal, and Advocate of Internal Improvements.]

(Continued from page 187.)

Although a system of rectangular lines, traced from given co-ordinate axes, will, in general, furnish the best *data* for computation, yet cases sometimes occur when those calculations have to be made either from computed curves, or curves actually laid upon the ground. In a first location this case will sometimes happen, when, from difficulties which are found in advance of a line, it becomes necessary to change a part of that which was either already computed, or actually laid. Such a case will sometimes occur, even when the operations in the field have been skilfully conducted; and in laying curves upon a surface already *graded*, it will be frequently necessary to compute from curves actually traced. The principles contained in the four last articles have been given chiefly with this object in view. But with regard to the two last articles, (7 and 8,) it may be observed, that, *when the curves are long*, it becomes very important to have some method of obtaining the *position* of the line w fromthe extremity of either curve; for a knowledge of only the *length* of that line will, in such a case, be of very little use in the field, unless the direction is also known, in order that the termination of any *proposed* curve may be immediately *pointed out* by an instrument placed at the termination of a given curve. There is no difficulty in obtaining very convenient formulas for the object thus proposed; but for want of room in this journal, I must proceed to other things.

10. *Take a system of rectangular co-ordinate axes, having their origin at a given station in a tangent line, from which a certain required curve is to be laid, passing through a point designated by the co-ordinates* x y; *the given tangent line coinciding with the axis of* x: *and let a system of rectangular lines be traced from the origin to the designated point, agreeably to the method proposed in article* 4. *It is then required to determine a method by means of which the instrument may be immediately directed into the true tangent at the designated point.*

Let the successive rectangular lines, as traced from the origin, be represented by $a\ b\ c\ d$, &c. It may then be observed that the safest method of recording the lines $a\ b\ c\ d$, &c., in the field, will be to take a blank form, $\begin{Bmatrix} x = \\ y = \end{Bmatrix}$, and then record each line in its proper equation, and with its proper *sign*, immediately as their values are determined by measurement.

A matter of considerable importance in the field, after the rectangular lines $a\ b\ c$, &c. have been traced to any proposed point, is to be able to examine, by the direction of the instrument, what the direction of the curve would be passing from the origin through that given point. Indeed, in difficult situations, a curve cannot be *selected* without such a datum; and if the rectangular lines $a\ b\ c$, &c. were *not sufficient* to furnish that datum with facility, a curve would have to be actually laid upon the ground, in order to judge of its fitness, even if a point were known through which it would pass. It would evidently be not difficult to direct the instrument, when placed at the given point, into the true tangent there, if the inclination of that tangent to the primitive tangent at the origin were known. For the last rectangular line traced will, of course, be either parallel to the primitive tangent, or perpendicular to it; and, in either case, it furnishes the means of directing the instrument into a line parallel to the primitive tangent at the origin. It is then only necessary to deflect an angle equal to the inclination of those two tangents, when that inclination is known, and the direction of the curve at the given point may then be perceived at once, from the position of the instrument, without that delay which would be occasioned by actually tracing a curve upon the ground, which must ultimately be relaid. The result, therefore, is, that a formula must be investigated, expressing the inclination of the two tangents in terms of the given co-ordinates $x\,y$. Take D to denote the inclination required; then $D = 2\,n\,T$, and consequently, by art. 2,

$$x = \frac{\text{Sin. D}}{2\,\text{sin. T}}, \text{ and } y = \frac{1\text{-Cos. D}}{2\,\text{sin. T}}.$$

Eliminating D from those two equations, the result is,

$$\text{Cot. } \tfrac{1}{2}\,\text{D} = \frac{x}{y}.$$

Such is the formula required, and its applications are very extensive in the field: for it will thus be seen, at once, whether or not the given point can be maintained; and this fact should be always ascertained, and the most judicious line definitely *selected,* before any curve is actually traced.

11. It is frequently necessary that several points should be designated, through which a curve is required to pass by means of a change of curvature at each of those points. To show the method of operation which ought to be pursued under such circumstances, take a system of rectangular co-ordinate axes, coinciding with the primitive origin and tangent line. Trace, parallel to those axes, a system of rectangular lines, given by the equations

$$\begin{Bmatrix} x = a + b + c + \&c. \\ y = d + e + f + \&c. \end{Bmatrix}$$

and terminating at the *first designated point.* Let the instrument be then placed at that point, and directed into tangent agreeably to the method explained in the last article. Take this second tangent as the axis of x, for a new system of rectangular co-ordinate axes; and parallel to these new axes, trace a second system of rectangular lines, given by the equations.

$$\begin{Bmatrix} x = a' + b' + c' + \&c. \\ y = d' + e' + f' + \&c. \end{Bmatrix}$$

and terminating at the *second designated point.* Let the instrument be now placed at this second point, and again directed into the proper tangent by the same means as bef. re. Take this third tangent as the axis of x, for a third system of rectangular co-ordinate axes; and parallel to this second new system of axes, trace a third system of rectangular lines, given by the equations

$$\begin{Bmatrix} x = a'' + b'' + c'' + \&c. \\ y = d'' + e'' + f'' + \&c. \end{Bmatrix}$$

and terminating at the *third designated point.* Continue this obvious order of proceeding, until equations

$$\begin{Bmatrix} x = \qquad\qquad \\ y = \qquad\qquad \end{Bmatrix}$$

have been obtained for *all the designated points;* and then by means of those equations, and article 4, compute all the moduli of curvatures. Returning now with the instrument to the primitive origin, let each curve be traced from its proper modulus of curvature, and the line will be found *to pass through all the designated points.* If proper care be observed in chaining the different systems of rectangular lines, by means of which the equations

$$\begin{Bmatrix} x = \qquad\qquad \\ y = \qquad\qquad \end{Bmatrix}$$

have been obtained, there can be no disappointment in the result; and, consequently, if the designated points have been judiciously selected, there will very seldem be a necessity of *tracing* the same part of a line *the second time;* and thus the method of co-ordinate axes, when skilfully conducted, will constitute one of the most important systems of operations connected with the location of railroad lines.

In tracing the various systems of rectangular lines through the different points which may be designated for a curve, there is a principle of practical convenience which must be mentioned. I mean the principle of designating such points *for a change of curvature,* as will cause each section of the whole curve, between the designated points, to be composed of an *integer number of chains,* when those curves come to be ultimately traced, after their respective moduli of curvatures have been ascertained by the methods explained above. It is indeed necessary in every case, except where the road-way is perfectly horizontal, to know the *length* of each of those separate curves, in order to select the designated point correctly with respect to *grade;* and this datum must therefore always accompany the levels. When a system of those rectangular lines have been traced to any given point, and the resulting equations

$$\begin{Bmatrix} x = \qquad\qquad \\ y = \qquad\qquad \end{Bmatrix}$$

have been thus obtained, the distance from the origin to that given point, in a right line, will obviously be truly expressed by $\sqrt{x^2+y^2}$; which is a formula rendered very convenient for use, by means of a table of the squares and square roots of numbers. And this quantity may be frequently taken as the length of the intervening curve, by which to compute what the *grade* would be at that given point, and will always furnish an easy method of obtaining the approximate distance necessary in making a selection for the *position of a line,* as far as the levels have an influence. The next object, then, must be finally to designate such a point as near the point fixed by the levels as a desirable curvature will permit, *and which will produce a curve, from the origin, containing an integer number of chains.* The preceding principles will furnish very simple means of obtaining the desired point; but I cannot *here* enter farther into such details.

12. *Let two curves be under consideration, having different origins, and tangent lines; and let one of those curves be given, from a system of rectangular lines or otherwise, and a point designated therein through which the other curve is required to pass. It is proposed to explain a method by means of which the modulus of curvature of the required curve may be computed.*

Take a system of rectangular co-ordinate axes, corresponding with the given origin and tangent line of each curve respectively, and let the co-ordinates of that point in the given curve which is designated for the required curve to meet, as taken with reference to the co-ordinate axes of the given curve, be $x\,y$; the values of these co-ordinates being computed by article 2, if the given curve be already laid in the field, but determined by means of a system of rectangular lines, when that curve has not been actually laid. Let the co-ordinates of the *new origin,* taken with reference to the axes of $x\,y$, and determined either by computation, or by means of a system of rectangular lines, be denoted by α, β; α *being supposed* to coincide with the axis of x. Take z to denote the given inclination of the tangents at the origins of the two curves.

It is sufficiently obvious that the required modulus of curvature will be immediately derived from article 4, when the co-ordinates x'

y', of the designated point, as taken with reference to the new origin and axes, becomes known. The formulas for those new co-ordinates are,

$$x' = \overline{y+\beta}\,.\ \text{Sin.}\,z + \overline{x+\alpha}\,.\ \text{Cos.}\,z$$

$$y' = \overline{y+\beta}\,.\ \text{Cos.}\,z - \overline{x+\alpha}\,.\ \text{Sin.}\,z$$

These are the well known expressions given by most authors for the transformation of rectangular co-ordinates, and they only here stand transposed in such a manner as will best suit the engineer's purpose in the present inquiry. By means of article 4, the above equations immediately produce the following formula, for the value of the new modulus of curvature T′:

$$\text{Sin.}\,T' = \frac{\overline{y+\beta}\,.\ \text{Cos.}\,z - \overline{x+\alpha}\,.\ \text{Sin.}\,z}{\overline{y+\beta}|^2 + \overline{x+\alpha}|^2}$$

The theorem thus obtained has a very good form for computation, and when skilfully applied, it will frequently save much labor in the field, which would be otherwise required, *when certain alterations are proposed in a line, once computed, or actually traced.* In the practical use of this theorem, particular attention must be paid to the algebraic *sign* of all the quantities; but this does not *here* require an explanation. VAN DE GRAAFF.

Lexington, Ky., April, 1834.

THE THAMES TUNNEL.—The completion of this great undertaking seems, if practicable, likely soon to be attempted, as several scientific and distinguished persons have lately visited it, and on Monday last Mr. Brunel received many of the members of the Royal Society to view it, and conducted them to its extreme end, where tables were laid out, having drawings, &c., showing the whole progress of the work, the great difficulties that have already been overcome in carrying the tunnel 600 feet under the Thames, and the data upon which the engineer confidently anticipated being enabled to complete this bold undertaking, were the necessary funds supplied. Mr. Brunel, at considerable length, detailed the exertions that have been used to overcome the difficulties arising from the irruption of the river, and stated that in the course of the work the miners had for twenty-seven days pushed on the tunnel over a quicksand. The members of the Royal Society, after leaving the tunnel, proceeded to view the experimental arch constructed on a new plan by Mr. Brunel. The structure is built with bricks and Roman cement, and consists of two semi-arches, springing from the same pier, without any support. By this plan an arch of the greatest span may be constructed without centering, and demonstrating, as the projector observed, the practicability of building a tower of brick-work 50 feet high, and 200 feet in diameter, and sinking the whole gradually in one mass. By this method it is intended to complete the circular and winding carriage approaches to the tunnel. It may be interesting to observe that of the two semi-arches one is shorter than the other, and it has been loaded with about eleven tons of iron for the last nineteen months, without any sensible change in its position. The company, after expressing their high satisfaction at the novelty of the works of the tunnel, and the last invention, partook of a cold collation.—[English paper.]

MECHANICS IN CANTON.—There is no machinery, properly so called, in Canton. Much of the manufacturing business, required for the supply of commercial houses in the city, is done at a town situated at a short distance; still the amount of labor performed in Canton is very considerable. There are about 17,000 persons in Canton employed in silk weaving. The number of persons engaged in manufacturing different kinds of cloth is about 50,000. They occupy 2,500 shops, averaging usually twenty hands in each shop. Some of the Chinese females, who devote their time to embroidery, secure a profit of from twenty to twenty-five dollars per month. The number of shoemakers is more than 4,000. Those who work in wood, brass, iron, stone, and other materials, are numerous; and those who engage in each of these occupations form a distinct community, and are governed by their own laws and regulations in their business. The *barbers* form a separate department. No man can act as tonsor without a license. The number of this fraternity in Canton is more than 7,000. The whole number of mechanics in the city is estimated at 250,000.

CLEANING FURNITURE.—The many accidents arising from the dangerous practice of boiling turpentine and wax for cleaning furniture induces me to send you, from my common-place book, a receipt for the mixture of these articles, which will prove a much superior and more effectual plan than that usually adopted, and by which so many individuals have lost their lives. Put the quantity of turpentine required into a vessel, then scrape the bees' wax into it with a knife, which stir about till the liquid assumes the consistency of cream. When prepared in this manner it will be good for months, if kept clean; and it will be found that the furniture cleaned with the liquor manufactured in this way will not stain with the hand so readily as when the boiling process is adopted. But if some people must have heat in the mixture, it can easily be got, by placing the vessel containing the turpentine and wax into another containing boiling water, which will do the business as well as any fire whatever.—[Architectural Magazine.]

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